



Time Dependent Valuation (TDV) – Economics Methodology

Extract of March 18, 2002 Report

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Overview

Past development and revisions of the Title 24 Energy Standards were based on electricity and natural gas costs that did not account for seasonal or time-of-use patterns (flat valuation of savings). These energy costs were based upon the annual average price of electricity (\$/kWh) or natural gas (\$/therm) paid by residential or commercial consumers throughout the state. However, both the price Californians pay for energy and the cost of delivering energy depends upon when and where the energy is needed. This proposal recommends using a more accurate energy costing analysis for the Standards, called Time Dependent Valuation of savings (TDV), which accounts for variations in cost related to time of day, seasons, geography and fuel type

The use of TDV criteria in the Standards to place a higher value on energy savings during the high cost times of the day and year, and which are more closely tied to the actual variations in energy costs, would encourage the design and construction of buildings which reduce the peak demands on the energy system in California. Over time, this would lead to significant cost savings for both building owners and for the utility system at large, along with improved reliability for utilities, customers and society at large.

Description

The heart of the TDV economics proposal is a methodology for deriving hourly valuations for electricity, natural gas and propane. Each set of values represents one class of buildings (residential, nonresidential), one of the three fuels, and one of the sixteen California climates. The geographical and temporal variability in delivered energy costs are due primarily to differences in commodity prices (electricity prices are higher in summer than winter, natural gas and propane prices are higher in the winter than summer). The methodology for electricity valuation includes generation, transmission, distribution, and a revenue neutrality adjustment. The resulting hourly valuations reward energy efficiency depending on when the energy is saved, with greater valuations during on-peak conditions and lesser valuations off-peak. In addition, the TDV method is based on long range forecasts of the total costs of electricity, natural gas and propane, so it provides for more realistic comparisons of the costs and savings associated with each energy source.

Benefits

The primary benefit of the TDV methodology is to give Title 24 a more accurate way to credit the value of energy savings than it currently does with its traditional flat valuation scheme. Buildings designed under TDV will be more economical for building owners, because they will consume less energy during peak conditions. As the effects of TDV-designed buildings spread across the state, there will be a reduction in electricity system peak demands, which will save Californians the cost of new power plants and distribution systems, and will help to make the electric system more reliable. Adoption of TDV by the State of California is an effective, long-term response to the energy crisis and the threat of blackout.

Environmental Impact

There are no direct environmental impacts associated with the adoption of TDV. Over the long run, there are likely to be general environmental benefits from the reduced need for peaking plants.

Type of Change

The adoption of TDV economics by the CEC would modify the calculation procedures used in making performance calculations. This change would not add a compliance option or a new requirement, but would affect the way that tradeoffs are made. TDV values would be incorporated into the ACMs (alternative calculation methods approved for use as compliance tools), and would be used internally by the computer programs in calculating the compliance margin for a given building design. This process would be transparent to the end user, to whom the inputs and

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outputs of the ACM would be substantially the same as under the current standards.

TDV economics would also be used for calculating the cost effectiveness of new measure proposed for adoption into Title 24. It is not contemplated that the existing standards and their cost effectiveness would be re-evaluated under TDV; the measures currently in place within Title 24 would remain as a given. Over time, new measures, which perform better under TDV, might displace older measures which do not perform as well during peak periods.

Adoption of TDV would require changes to the ACM manuals, so that the compliance tools can correctly implement TDV. Concurrent changes made to the Title 24 engineering calculations to better implement TDV might require some adjustments to the simulation inputs to better account for measure performance (e.g. a more detailed HVAC equipment model might require more detailed inputs).

Technology Measures

Time Dependent Valuation is not a technology measure

Performance Verification

Time Dependent Valuation does not require performance verification.

Cost Effectiveness

TDV does not, in itself, need to pass any cost effectiveness tests. Rather, it provides an economics methodology for performing a new kind of cost effectiveness analysis on proposed measures.

Analysis Tools

Implementation of TDV will entail adding a new step to the calculation of energy savings in a measure. The hourly energy savings values are each multiplied by an hourly TDV factor. The results for each hour are summed over the entire 8760 hourly savings valuations for the analysis year. The TDV factors are different, depending on which of the three energy sources (electricity, natural gas, propane), which climate zone and which class (residential, nonresidential) is in question. The calculations, however, would be done internally and automatically within the compliance tools (e.g. MICROPAS, EnergyPro).

Relationship to Other Measures

The TDV economics methodology can be adopted on a stand-alone basis and applied as a new valuation methodology to the current Title 24 implementation. However, in order to realize the full benefits of TDV, we recommend that there be a number of upgrades to the engineering analyses associated with performance trade-offs and compliance. All of these engineering enhancements provide for better hourly analysis of savings, and hence more accurate treatment of those savings under TDV.

The most obvious example of a TDV engineering enhancement that should be made is in the modeling of residential HVAC systems performance. Under the current residential ACM models, the annual cooling load is calculated using an hourly loads analysis in MICROPAS. The total annual load is then simply divided by the SEER to get the annual cooling energy. If TDV is adopted, this calculation should be changed to incorporate an hourly HVAC equipment model, so that the cooling energy use is calculated for each hour. The TDV hourly factors can then be applied to these hourly energy numbers. In addition to the improved accuracy of this calculation, it would also allow Title 24 to distinguish between air conditioners which perform well under high temperatures from units which do not. Residential Title 24 could then be used to encourage or give credit for the better performing equipment.

TDV would still work without a residential HVAC equipment model, but the value of improved air conditioning would not be treated as accurately. Residential envelope measures, which are already modeled on an hourly basis,

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would be relatively more sensitive to performance trade-offs.

There several additional TDV engineering enhancements that we will be recommending for adoption alongside this TDV economics proposal. Most of these are still in the final stages of development as of this writing, but they are expected to be completed in time for adoption under the current standards proceeding. There will be a separate CASE report prepared to explain and justify each TDV engineering enhancement. These include:

- Residential Hourly HVAC Model
- Residential Hourly Water Heating Models
- Nonresidential HVAC Equipment Modeling Enhancements
- Nonresidential Hourly Schedules Enhancements

The TDV engineering model enhancements listed above have been under development by the PG&E TDV team. Once the TDV economics methodology has been accepted by the CEC for use with Title 24, it is likely that others may propose additional engineering enhancements that provide more accurate hourly savings calculations for use with TDV. We assume that these will be discussed and adopted on their merits under the normal CEC standards review process.

TDV Economics Methodology

A detailed description of the TDV economics methodology and its derivation is attached as Appendix XX, a document entitled *Time Dependent Valuation (TDV) Formulation 'Cookbook'* (TDV Cookbook for short), dated March 15, 2002. This document is also available for download from the project web site: www.h-m-g.com – follow the hyperlink from the home page. What follows is a brief overview discussion of the TDV economics methodology.

Goals of Methodology

In developing the TDV methodology, we began with a review of the various ways that energy savings could be valued. A joint study by the CEC and PG&E, done in 1998-99, entitled *Dollar-Based Performance Standards¹*, looked at the forecast costs and the marginal costs for electricity, propane and natural gas, examined available sources of data, and explored the feasibility of using a dollar-based valuation scheme for Title 24. As a result of that study, we set several goals for the ultimate TDV methodology:

1. **Repeatable methodology** – the TDV valued would have to be updated from time-to-time, perhaps with each 3 year standards cycle, so it needs to have a clearly documented, repeatable method for developing the TDV factors.
2. **Publicly available data sources** – in order to be repeatable and defensible, the data inputs need to be available for public scrutiny
3. **Valid for a long-term efficiency perspective** – the Title 24 standards provide design signals for buildings that will have a life of 15 years, 30 years, or more. The TDV method should not reflect short term fluctuations in the energy markets, but should be based on reasonable, conservative, long-range forecasts of energy costs
4. **Not based on rates or tariffs** – while it is true that customers see rates, and the dollar savings they gain from efficiency investments are a function of those rates, rates do not provide a good basis for setting long-term efficiency goals statewide. Rates change by utility and often by year. Rates reflect many factors besides the costs of energy, including public policy (e.g. low-income assistance), customer class cross-subsidizations, utility marketing strategies, etc. TDV needs a basis that is more directly tied to the true costs of power to Californians, and that will be stable over time.
5. **Reflects the overall costs of energy** – TDV should not be based solely on the marginal costs of energy, which are lower than the total costs. If only the marginal costs were included, then the value of savings would be lower than Title 24 has traditionally valued savings, and the overall stringency of the standards would be reduced. By accounting for the total costs, by adjusting TDV valuation to reflect the total revenue requirements of the utilities, we more realistically value the savings of measures, and we also avoid back-sliding on the stringency of the Title 24 standards.

The historical, flat energy costing or valuation methodology of Title 24 assigns the same value to energy savings regardless of the time of day, season of year, temperature or any other of the differences known to affect the value of energy. By contrast, TDV assigns a different value for energy to each hour, depending on a variety of factors. Figure 1 compares the TDV and flat energy values for a representative summer weekday. Any point on the curve represents the value of a unit of energy savings for the given hour. Under TDV, energy saved during a peak hour has a higher value than the same savings under flat energy valuation; conversely, energy saved during an off-peak hour is valued less under TDV than under flat valuation.

¹ Heschong Mahone Group. *Dollar-Based Performance Standards for Building Energy Efficiency--Final Report*, 1999. For Pacific Gas & Electric Company.

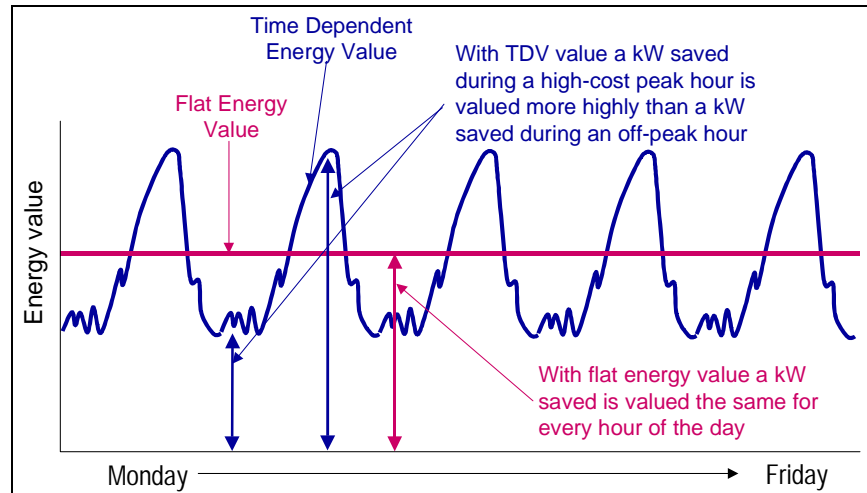


Figure 1 - TDV Costing Compared to Flat Costing – summer weekday

The consequences of TDV versus flat valuation follow from these observations. A measure whose savings are primarily during on-peak periods throughout the year would be more highly valued under TDV than under the present, flat valuation regime. An example of this would be high performance glazing in a west-facing window. Similarly, a measure whose savings are primarily during off-peak periods would be valued less than under TDV. An example would be economizer cooling, which provides free cooling during cool weather, but which does not operate during peak conditions.

Many measures, however, save energy all the time, and so over the course of a year are valued about the same under either TDV or flat valuation. For example, wall insulation reduces both heating and cooling loads, during both the summer and the winter, so the high and low TDV savings balance out. This is because the areas under the two curves in Figure 1 are equal over the full 8760 hours of the year.

Development of TDV Factors

The development of hourly TDV factors for electricity includes several components, as illustrated in Figure 2. It begins with the CEC's forecast for generation costs (labeled PX), which varies by month, day of week and time of day. Then it adds the transmission and distribution costs (T&D), which are assigned to the hottest hours of the year to reflect the fact that T&D costs are driven by peak temperature events. Next, the revenue neutrality adjustment is added, which brings the annual cost of energy into line with the statewide electric utility revenues, a proxy for the cost of electricity to ratepayers. Finally, an environmental externalities adder is applied, which reflects the cost of emissions from the least efficient power plants that are brought on-line during times of peak generation. The costs which are added up are life cycle costs, discounted back to present value assuming the CEC's standard 3% discount rate and a time period of 15 years for nonresidential buildings and 30 years for residential. The last step in the process is to convert the dollar values into equivalent energy values; these are analogous to the traditional source energy units used by the CEC for valuing energy savings.

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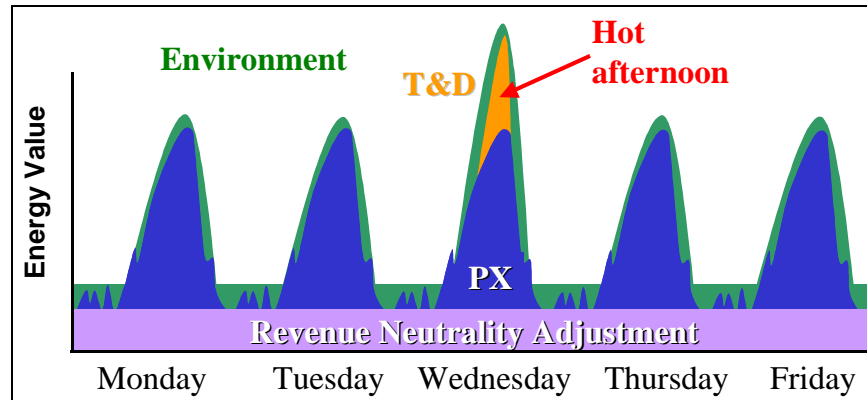


Figure 2 - Components of electricity TDV values during a hot summer week

This process produces a set of 8760 hourly values for the typical year represented by the weather tapes used for Title 24 energy analysis. Consequently, there are different sets of values for each of the 16 California climate zones. This is important, because these weather tapes are used in the hourly building energy simulations for Title 24 compliance, and it is the peak conditions that the buildings experience in these models must match with the peak hours of savings valuation under TDV. A representative graph of the 8760 values for nonresidential buildings, using climate zone 13 data, is shown in Figure 3. These values are in present value dollars; they have not yet been converted into TDV energy units. This graph illustrates how the value of electricity savings is greatest during the hot, summer afternoon hours, and lowest during the winter months.

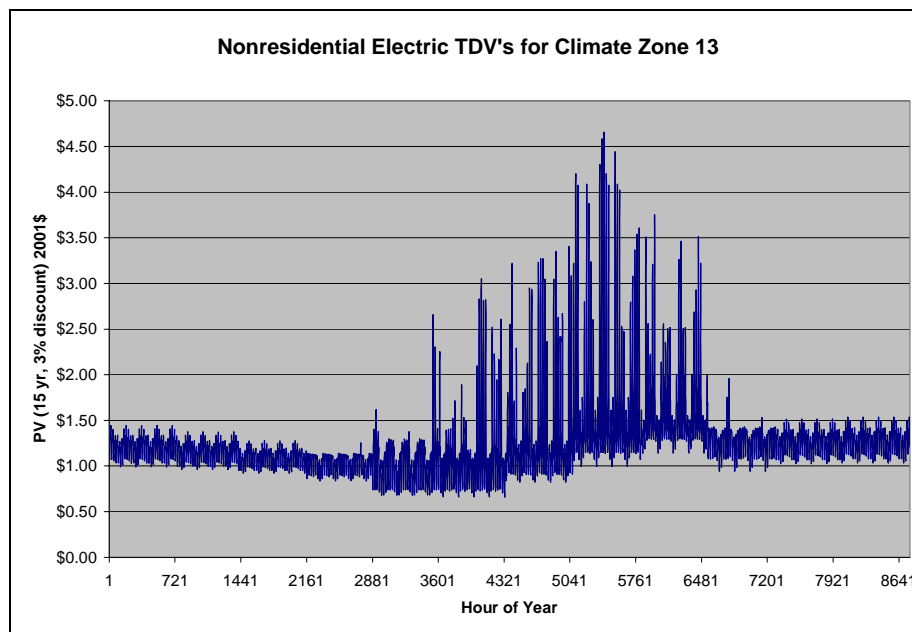


Figure 3 - Profile of TDV Electric Costs for CTZ 13

The process for generating natural gas and propane TDV energy values is similar to that for electricity, but it is simpler because they only vary monthly, not by day or by hour. The shape and components for the annual TDV values of gas are shown in Figure 4.

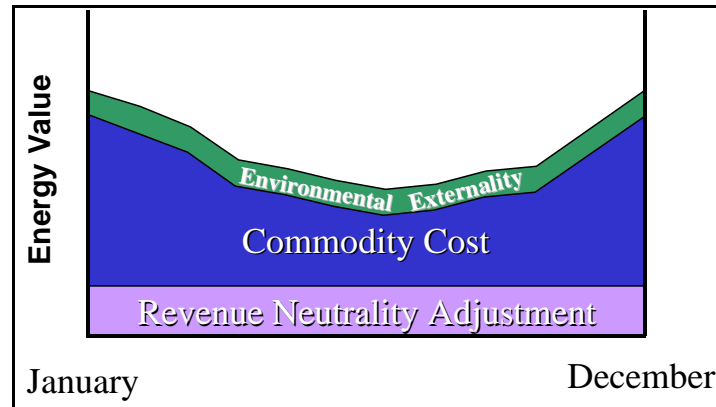


Figure 4 - Components of Gas TDVs

Environmental Externality Option

The environmental externalities parameter has been included for consistency with the CPUC's method for valuing energy savings in programs which use public benefits charge monies. It was developed using conservative assumptions of the costs of CO₂ and NO_x, and, for electricity, associating these with the hours of peak generation in California. The environmental externality component of costs is applied uniformly to gas and propane energy savings, because CO₂ and NO_x are generated whenever these fuels are consumed. The question of environmental externalities can be exceedingly complex and controversial, so our method has emphasized a straightforward and defensible approach. It would, of course, be possible to develop a more aggressive and complicated method. The net result of our approach is to increase the "peakiness" of electricity TDV factors. The portion of annual TDV savings attributable to the environmental externality will, of course, vary according to the measure and its time-of-savings characteristics. A representative comparison is shown in Figure 5, which compares the average life cycle cost valuation of a kWh of savings for a residential and a nonresidential building. The higher valuation for the residential case reflects the fact that a 30 year life cycle is assumed, versus a 15 year life cycle for nonresidential. The lower segment in each column is the generation component (Gen). The next segment is the transmission and distribution component (T&D), followed by the revenue neutrality adjustment (Retail). Finally, the top segment in each bar is the environmental externality component (Env). As with Figure 3, these are in units of LCC dollar valuations, before they are converted into TDV energy units.

Figure 5 illustrates the fact that the environmental externality is a small component of the overall TDV method. While we feel that including an environmental externality as part of TDV is warranted and reflects reality, we do not believe that it has a substantial effect on compliance outcomes or other Title 24 concerns, and it could be dropped without diminishing the fundamental value of TDV.

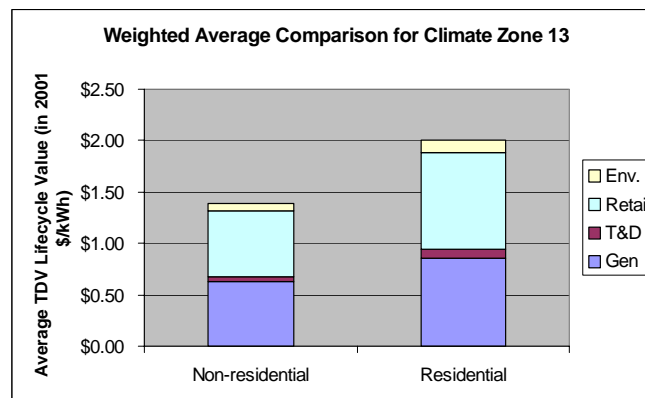


Figure 5 - Components of TDV Electric Values for Climate Zone 13

TDV Data Sources

The data sources used to derive the electricity, natural gas and propane TDV factors are listed in Table 1.

Table 1 - Data Sources Used in the TDV Methodology

Data	Source	Vary by Climate Zone?
Weather Data	Climate zone data used for standards evaluation	Yes - each zone has its own weather
Electric Class Shapes	1999 utility statistical load profiles used in billing	Yes - varies by utility
Electric Retail Rates Forecast	CEC forecast 2005 to 2034 for each IOU, res and non-res	Yes - varies by utility
Annual Wholesale Electric Price Forecast	CEC forecast 2005 to 2034 for each IOU	Yes - varies by utility
Hourly wholesale electric price shape	CEC (shape based on Richard Grix forecast)	No - system value used in all CZs
2005 Natural Gas Wholesale Price used in estimating electricity emissions component	CEC forecast average 2005 EG cost for each IOU	Yes - varies by utility
Emission rates by power plant type	E3 study	No
Emission costs by pollutant	E3 study	No
Natural Gas TDV Streams	CEC forecast retail gas rate - monthly 2005 to 2034 - residential and commercial	Yes - varies by utility
Oil Price forecast (propane assumed to follow oil price trend)	DOE EIA projection of oil prices through 2019, extended through 2034 by 10 year trend	No
Monthly propane price shape	DOE EIA Petroleum Marketing Monthly publication	No
Monthly propane consumption shape	DOE EIA Petroleum Marketing Monthly publication	No
Average propane price	DOE EIA Petroleum Marketing Monthly publication	No

A more complete and comprehensive description of the derivation of the TDV methodology, and the use of these data sources, is found in Appendix A, where the TDV Cookbook is reproduced.

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Tables of summary statistics on the time dependent valuations derived for each of the sixteen California climate zones are presented in Appendix B. These tables indicate the ranges of present value numbers, in dollars, including minimum and maximum values, averages and standard deviations within the sets of 8760 hourly values.

One of the key aspects of the TDV economics methodology is the forecasts upon which the numbers are based. Over time, as available information is updated, the forecasters are likely to revise their forecasts, which should logically result in revised TDV numbers. As described in the TDV Cookbook, however, creating the TDV numbers is a multi-step task. Recreating the TDV numbers as forecasts change is not necessary nor recommended unless the forecasts have changed significantly. For slight changes in forecasted values of any of the fuels, one can multiply all the values by a scalar that adjusts the weighted average TDV's, as shown in Appendix B, up to the revised forecast value.

In addition to the derivation of the TDV economics values, shown in Appendix A, Appendix C contains a description of the method of conversion from TDV dollars (the LCC present value numbers used in previous discussions) into TDV energy units. This is the final step in the creation of the TDV numbers recommended for adoption into Title 24.

TDV Analysis Results

The development of TDV numbers is the heart of this proposal, but many stakeholders are more interested in how TDV will affect the Title 24 standards and compliance outcomes for real buildings. This section describes a suite of analyses conducted to try out TDV in a compliance-like setting, and to demonstrate how it affects the trade-off of measures and building features.

Details omitted in this extract...

TDV Analysis Results - General Conclusions

From inspection of the results of this analysis, the following general comments can be made:

- For measures that involve electricity savings, TDV savings are significantly higher than those from source energy comparisons. There are two components of this additional savings:
- Source energy uses a ratio of 3:1 to compare natural gas and electricity, yet the average value of electricity used for evaluating the cost-effectiveness of the standards is 4:1 and up. TDV is based upon the economic valuations and gives a higher value to electricity even if time and temperature dependency were not included.
- Most of the electricity savings measures tended to save more during the times of peak and thus were valued yet higher than by a mere comparison of the average value of energy sources.

We conclude that TDV is giving the correct kinds of signals to the construction market to design buildings that reduce peak demand. The California efficiency standards should incorporate TDV into the cost-effectiveness analysis of prescriptive requirements and the performance methods as defined in the Alternative Compliance Method (ACM). This will ensure that the two methods are in concordance and simplify moving trade-off measures typically chosen by designers into the prescriptive standards.

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